

## **Pest Management Grants Final Report**

Rice Water Weevil Management: Development of Improved Sampling Techniques and Rice Yield Loss Understanding for Optimizing IPM in California Rice

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### **Acknowledgments**

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## Table of Contents

List of Figures and Tables .....	5
Executive Summary .....	6
Report .....	7
Introduction .....	7
<i>Objective 1</i> .....	7
<i>Objective 2</i> .....	8
Materials and Methods .....	9
<i>Objective 1</i> .....	9
<i>Objective 2</i> .....	10
Results .....	10
<i>Objective 1</i> .....	10
<i>Objective 2</i> .....	11
Discussion .....	12
Summary and Conclusions .....	12
Appendix .....	13
Publications .....	13
Tables 1-4 .....	13
Figure 1-5 .....	16

## **List of Tables and Figures**

	Page Num.
Table 1. Sample dates for floating barrier trap study, 2002.	13
Table 2. Leaf scarring, RWW larval populations, and trap capture data from floating barrier trap study, 2002.	14
Table 3. Key dates of sampling, leaf scarring, RWW larval populations, and trap capture data from seeding date versus floating barrier trap study, 2002.	14
Table 4. Statistics from linear relationships between RWW numbers and yield loss, 2002.	15
Figure 1. Percentage of RWW adults captured by floating barrier traps at various rice growth stages.	16
Figure 2. Relationship between RWW adult capture in floating barrier traps and RWW larval populations; summary of 9 fields, 2002.	16
Figure 3. Comparison of results from floating barrier trap in 2001 and 2002.	17
Figure 4. Influence of RWW population density on floating trap collections, 2002.	17
Figure 5. RWW flight timing as indicated with light traps, note that 2001 and 2002 data are graphed on different scales.	18

## EXECUTIVE SUMMARY

The switch from applications of preventative, preflood, granular insecticides to foliar, post-flood materials for rice water weevil (RWW) control in California rice has opened up opportunities for refined IPM in this system. However, applied research is needed to develop the information required to enhance these IPM programs and that is the goal of this research. These new insecticides were registered in 2000 as the long-time standard product, carbofuran, was removed from the market. The use of a post-flood material may allow the inclusion of field sampling and decision guides before insecticide application. An aquatic floating barrier trap was developed in southern rice for this use and the applicability of this trap to California conditions was evaluated in 2002 in nine rice fields. These results compliment a similar study done in 2001. In addition, this trap is being researched in the southern rice system and our results will dovetail with their results, albeit there are considerable differences between California and southern rice systems. In summary in 2002, the floating barrier traps functioned well and captured RWW in eight of the nine fields. The majority of the RWW (86%) were captured by the 2-leaf rice stage, i.e., within ~7 days of seeding and trap placement in the field. At this stage of growth, all the vegetation is below the water surface. Additional small plot studies were conducted at the Rice Experiment Station to answer specific questions about RWW sampling with this trap. Areas examined included the influence of RWW density, plant growth stage, and RWW flight timing on trap efficiency. Interesting data were obtained from two of these three additional studies; one of these studies was hindered by poor seedling establishment. As in 2001, there was a weak linear relationship between adult captures and the resulting larval numbers. As more adults were trapped in a field, there were more larvae in the samples a few weeks later with the relationship indicating slightly less than 0.7 larva per trapped adult. The area that was studied in this project was the relationship between timing of RWW infestation and rice yield response. These data are important to respond to the questions from growers that “season-long” RWW control is not possible with the new insecticides and that multiple applications may be needed. The 2002 results were intended to support the 2001 data in this area. The design was to infest small plots with RWW adults (two different densities + an uninfested) at five different rice growth stages to simulate infestations after an insecticide treatment has subsided. Unfortunately in 2002, this study had to be abandoned due to inadequate seedling establishment

## A.) Introduction

### Objectives

1.) *Investigate the existing monitoring protocols for determining the need for Rice Water Weevil treatment, and refine/develop additional monitoring techniques that may be useful for determining the need for treatment.*

Hypothesis 1: There is a relationship between the number of RWW adults captured prior to the 4-leaf stage and the number of RWW larvae (the damaging stage) feeding on the rice roots.

Hypothesis 2: The adult RWW population density in a rice field can be estimated through a relative sampling method such as a floating trap.

Hypothesis 3: The floating RWW trap developed in Arkansas, with modifications, will be useful to representatively sample RWW adult populations in California.

- **Task 1: select grower cooperators for studies**

Excellent cooperation was obtained from eight growers. This involved leaving a rice basin untreated in terms of rice water weevil and allowing us to collect samples in this basin.

- **Task 2: fabricate/repair traps designed to capture a representative number of RWW adults**

Floating traps were designed and made at UC-Davis. We followed basically the same design as that published from Arkansas researchers.

- **Task 3: place floating traps in rice fields within 2 days after rice seeding**

Traps were placed in each field within 2 days after rice seeding, most on the day of seeding. Each floating trap was placed ~10 feet from the field border and anchored. Eight traps were placed in each field along one edge of the field. Each trap was at least 50 feet apart. A light trap was operated at three of the sites so we could look at the relationship between RWW flights (shown by the light trap) and captures in the floating barrier traps.

- **Task 4: monitor traps every 2 days and collect captured RWW adults**

Adult RWW were collected from traps every 2 days. Traps were cleaned of debris and other arthropods. Light traps were emptied and batteries changed concurrently with the floating trap service.

- **Task 5: record field conditions**

Field conditions were recorded including rice growth stage, water depth, etc at the same time as trap servicing. Traps were removed from the field at the 7 leaf stage.

- **Task 6: evaluate RWW larval populations**

RWW larval populations were quantified near the location of each trap (location was marked with a flag since traps had been removed). Core samples (44 in<sup>3</sup>) were collected twice during the season at 6 and 8 weeks after rice seeding. Five core samples were collected per date per trap location. The RWW larvae were recovered from the mud sample using a washing-flotation technique that we have used for the last 10 years.

- **Task 7: data analyses**

Correlation analyses were done with SAS between the number of adults collected and RWW larval populations; significant correlations between these two parameters determined trap feasibility. Trap captures were compared against RWW adults collected in a nearby light trap.

- **Task 8: reporting data to grower cooperators and appropriate reports**

I participated in the Rice field Day held at the Rice Experiment Station in Aug. 2002 with an oral presentation and a poster. A yearly progress report was written for the growers in Dec. 2002. Results were reported, at the national level, to the S-300 meeting, "Mosquito and Agricultural Arthropod Pest Management in Rice and Natural Wetlands". Internationally, I plan to present the results at the Temperate Rice Conference in March 2003 in Uruguay.

*2.) Evaluate the relationship between Rice Water Weevil induced injury and rice yield at various plant growth stages so as to determine the length of time that RWW control is warranted.*

Hypothesis 1: RWW larval infestations will reduce rice grain yields with infestations established at the 3-leaf stage.

Hypothesis 2: As the rice plant develops, it becomes more tolerant to RWW- induced injury.

Hypothesis 3: Rice plants reach the point where RWW injury does not effect grain yields and the point where this happens can be determined through well planned studies.

- **Task 1: select field site for study**

A site was selected at the Rice Experiment Station for this study.

- **Task 2: set up aluminum rings for the plots**

The evaluations were done in ring plots (8 ft<sup>2</sup>).

- **Task 3: seed rice into plots**

Immediately after the field is flooded, rice was seeded into each ring. 'M-202', a commonly grown variety, was used. Seeds were soaked for 24 hrs. and drained for 24 hrs. before seeding.

- **Task 4: cover rings with row cover**

Ring plots were covered immediately after seeding with floating row cover material to maintain the integrity of the treatments. This material was cut to the appropriate size in the laboratory. A fastener was fabricated out of rubber tubing and twine to hold the material in place. Row covers were removed 1 wk. after the last RWW treatment was established.

- **Task 5: infest rings with RWW adults**

RWW adults were collected from nearby fields and released into the rings on specified dates and numbers. For the timing treatments, infestations were done at 1.) first rice emergence through water (2.5-3 leaf stage), 2.) 7 days later, 3.) 14 days later, 4.) 21 days later, 5.) 28 days later, 6.) 35 days later, and 7.) 42 days later. On each date, the RWW number treatments were 1.) 0 RWW adults/plant, 2.) 0.4 RWW adults/plant, and 3.) 0.6 RWW adults/plant.

- **Task 6: establish a consistent plant population**

Plant populations in each ring were thinned to 12 plants per sq. ft. This allowed the effects of each treatment to be compared independent of differences in initial plant stand.

- **Task 7: evaluate RWW feeding scars**

RWW adults leave slit-like feeding scars on rice leaves. This damage is correlated with adult population density and was the sample technique used for Furadan post-flood economic threshold. This damage was quantified ~1 week after each infestation timing by examining 50 plants per ring and recording the incidence of feeding scars.

- **Task 8: evaluate RWW larval populations**

RWW larval populations were quantified in each ring. Core samples (44 in<sup>3</sup>) were collected twice



during the season at 6 and 8 weeks after rice seeding. Five core samples were collected per date per ring. RWW larvae were recovered from the mud sample using a washing-flotation technique.

- **Task 9: evaluate rice grain yields**

Rice grain yields were determined by cutting plants within each ring at soil level, weighing the straw + grain, threshing out the grain with a Vogel mini-thresher, cleaning the grain sample, weighing the grain, and determining the % grain moisture. Grain yields were standardized to 14% moisture.

- **Task 10: data analyses/interpretation**

Data were analyzed using SAS.

- **Task 11: reporting data to grower cooperators and appropriate reports**

## **B.) Materials and Methods**

Objective 1. In 2002, we placed traps at 9 locations (8 grower fields and the Rice Experiment Station). Each field had eight traps, secured ~10 feet from the levee and 50-60 feet apart. They were put out within 2 days of seeding and checked 3 times per week. Captured RWW adults were counted and removed, records were kept for water depth and plant growth stage and the traps were cleaned of algae and debris. Trap data were collected until the rice began to tiller. Scar counts were taken from each site at the 4-5 leaf stage. Core samples for RWW larvae were taken at 6 and 8 weeks following seeding. They were processed by washing through a fine mesh screen and counting the number of immature RWW. These data were used to establish a ratio between trap catches and larval densities. A summary of key dates is in Table 1.

Based on results from the 2001 studies, several additional questions arose about the usefulness of this trap. Questions such as 1.) how closely do the trap catches of RWW represent the field RWW population, 2.) how closely linked are the trap catches and RWW flight as indicated with a light trap, and 3.) what is the relationship between rice growth stage and trap efficacy in capturing RWW adults were addressed in additional studies.

How closely do the trap catches of RWW represent the field RWW population? To address this question, 28 sq. ft. rings were seeded with M-202 on 10 May and immediately covered with floating row cover material to prevent invasion by naturally-occurring RWW adults. RWW adults were collected from a nearby field and infested into the rings when the plants were in the 2-leaf stage. Four treatments were established, 0 RWW adults per sq. ft., 1 RWW adult per sq. ft., 3 RWW adults per sq. ft., and 5 RWW adults per sq. ft. Simultaneous with this manual infestation of RWW adults, one floating barrier trap was placed in the middle of each ring. Traps were checked three times per week for trapped adults. Scar counts were made at the 4-leaf stage to quantify adult survival and feeding.

How closely linked are the trap catches and RWW flight as indicated with a light trap? Plots measuring 50 x 50' were seeded with M-202 on four sequential dates 3 May, 10 May, 17 May, and 24 May. Each plot was flooded 1-2 days before seeding. Four floating barrier traps were placed in each plot soon after seeding and maintained until the 5 leaf stage. A light trap was operated adjacent to this plot at the Rice Experiment Station. Data were collected three times per week from the floating barrier traps and from the light trap.

What is the relationship between rice growth stage and trap efficacy? Rice was seeded into 28 sq. ft. rings on 10 May and the plots were covered with the floating row cover material. The goal was to infest the plots with 2 RWW adults per sq. ft. at the 1, 2, 3, 5 and 7 leaf stages. Upon infestation, one floating barrier trap was placed into each plot to see how effectively it captured adults. Traps were to be checked three times per week.

Objective 2. Studies were conducted at the Rice Experiment Station; plots were seeded on 10 May. However, at about the 3-leaf stage it became obvious that a seed midge infestation had severely reduced seedling establishment. A rescue treatment was impractical given the type of infestation and intended use of the plot, so this detailed study was abandoned.

A portion of the rings were re-seeded successfully on 3 June and some interesting data were obtained. Infestation levels of 0, 0.3, and 0.6 RWW adults per plant were used. Unfortunately, due to this late re-seeding date, we were only able to infest rings at the 2-leaf stage. Collection of a sufficient number of weevil adults for the other infestation timings was impossible. The standard RWW scarred plant, larval, and yield evaluations were carried-out. In addition, some data were obtained from two other studies conducted in 2002, including the previously detailed study on trap catches of RWW versus infestation level. However, the loss of the initial plots greatly hindered our progress on this objective.

### **C.) Results**

Objective 1. Table 1 shows the details for sampling dates, etc. for this study. Seeding dates ranged from 23 April to 1 June. Traps were placed in fields within 2 days of seeding. Traps were serviced from 6 to 16 times depending on the field and on the growth of the rice. Scar count data were collected once per field when the plants were in the 3-4 leaf stage; this corresponded with 22 May to 21 June, depending on the field. Larval core samples were collected twice per field from 26 June to 25 July. Samples were processed as time allowed either soon after sampling or over the next few months using frozen samples.

The total number of RWW trapped at each site and the corresponding percentage of RWW feeding scars and larval population are shown in Table 2. At locations B and L, fairly high levels of feeding scars were found but weevil numbers caught in the floating traps and larval number were low. These fields were planted fairly early and possibly avoided early RWW infestations. At the other locations, trap catches were indicative of scarring levels. Sites W and SP had high numbers of trapped adults, scarred plants, and larvae. Overall in grower fields RWW were captured at 8 of the 9 locations with a peak of 24.75 adults per trap per day in one field. No RWW adults were trapped in Location A, scar counts were very low and larval numbers were nearly zero. A high percentage (58%) of the adults was captured by the 1-leaf stage; this was surprising given the amount of foliage present for the RWW adults to feed upon and the short period of time in which the field had been flooded (Fig. 1). By the 2-leaf stage, 86% of the RWW had been captured. These data agree with that found in 2001 studies. This bodes well for the usefulness of the trap as this period corresponds to when management decisions must be made, but these results were surprising to me.

RWW immatures were sampled twice from each field in close proximity to the trap locations. These data were used to examine the relationship between trap catch and larval population. Although there was considerable variation in the data, the results did show a relationship between adult captures and the resulting larval numbers (Fig. 2). The relationship was a weak linear relationship between these two parameters. As more adults were trapped in a field, there were more larvae in the samples a few weeks later. In 2002, for every adult captured in a trap, about 0.6 RWW larvae resulted. Similar studies in 2001 showed about 1 larva per every trapped adult (Fig. 3).

#### How closely do the trap catches of RWW represent the field RWW population?

Traps collected more RWW adults in rings that were infested to a greater degree with RWW adults. Trap captures averaged 0, 1, 2.25, and 8 RWW for the 0, 1, 3, and 5 RWW per sq. ft. infestation regimes, respectively. Most of the RWW were captured at early plant growth stages (Fig. 4). In summary, the traps collected from 4 to 6% of the adults in the rings. The goal is for the traps to collect a constant percentage of adults across infestation level and that appears to be valid.

#### How closely linked are the trap catches and RWW flight as indicated with a light trap?

No RWW were captured in the first planting date in floating barrier traps from 6 May to 5 June (Table 3). Scarred plants averaged 28.5% from this planting date, a moderate value. Low numbers of RWW adults were collected in the other three planting dates. Percentage scarred plants was highest in the third planting date at 69%. Larval populations were higher as the planting date proceeded later in the season. RWW flight, occurred on 6 May, 13-15 May and 24-31 May. Floating traps collected adults during the last flight period, but also on 17 May and 5 June, when no flight was occurring. Light traps were also operated at two of the grower fields. The timing of RWW captures in the traps and flights as indicated by light traps did not correlate. In fact, at one location the light trap captured 869 RWW over a 5-day period and the floating traps captured no RWW. On this date, the rice was in the 5-leaf stage and at this time the traps do not seem to catch adults very well. Regardless, there were high numbers of adults moving around in the area and none were captured. Conversely, in this same field, the floating traps captured adults from 15 to 20 May and the light trap captured zero. Therefore, there appears to be a high degree of independence between floating trap captures and flight incidence.

#### What is the relationship between rice growth stage and trap efficacy?

Seedling establishment was very poor in this plot area due to a seed midge infestation and the study had to be abandoned.

Objective 2. RWW scarred plants averaged 0, 88, and 64% for the 0, 0.3, and 0.6 RWW adults per plant treatments, respectively. RWW larval numbers averaged 0.1, 2.9, and 3.5 RWW per core sample for the 0, 0.3, and 0.6 RWW adults per plant treatments, respectively. Grain yield was reduced by RWW infestation. Data from three studies were used to examine the relationship between RWW larval numbers and grain yield. Results are shown in Table 4. Yield losses per RWW larva ranged from 3.7 to 4.9%; the loss was less on the later seeded rice compared with the rice seeded on the “normal” early May date. However, the primary goal of this study, i.e., the

study of yield losses at various plant growth stages could not be examined.

#### **D.) Discussion**

Growers and PCAs had the most involvement with Objective 1 of this study. They were interested in these results and some were enthusiastic trying these techniques. The Rice Entomologists in AR, TX, and LA are also working with the floating barrier trap and, combined with their results, we are obtaining a “clear picture” about this trap. This trap is nearing the stage for demonstration. I plan to continue some of the small plot studies with it in 2003 and this will help to answer some questions.

#### **E.) Summary and Conclusions**

Overall, I believe the project was successful. Objective 1 was fully completed as outlined; unfortunately, due to poor seedling establishment, only one year of data (2001) could be conducted towards Objective 2. Those results were in conflict with preliminary results collected in 2000. Therefore, this question remains unanswered and growers will still be faced with this uncertainty.

## APPENDIX

### *Publications*

Godfrey, L. D. and R. R. Lewis. 2002. Management of rice water weevil with insecticides. Oral presentation and abstract (p. 34-36) at the Rice Experiment Station Field Day, Aug. 28, 2002.

Godfrey, L. D. and R. R. Lewis. 2002. Monitoring rice water weevil adult populations to improve management. poster and abstract (p. 9-11) at the Rice Experiment Station Field Day, Aug. 28, 2002.

Godfrey, L. D. 2003. Management of invertebrate pests in rice. Rice Production Workshop. Oral presentation and handout. Feb. 25 and 28, 2003.

Table 1. Sample dates for floating barrier trap study, 2002.

Location	Seeding Date	Floating Barrier Trap Sample Dates	% Scarred Plant Evaluation	RWW Larval Sampling
B	5/16	5/17 – 6/12	6/7	7/10, 7/25
A	5/2	5/6 – 5/29	5/22	6/26, 7/10
L	4/23	4/25 – 5/29	5/22	6/26, 7/10
W	5/13	5/15 – 6/10	6/7	6/28, 7/12
O	4/25	4/25 – 5/29	5/22	6/26, 7/10
M	5/10	5/10 – 6/10	6/7	6/28, 7/12
SP	5/14	5/15 – 6/10	6/7	6/28, 7/17
ST	6/1	6/3 – 6/21	6/21	7/10, 7/25
RES	5/10	5/15 – 6/10	6/7	7/5, 7/18

Table 2. Leaf scarring, RWW larval populations, and trap capture data from floating barrier trap study, 2002.

Location	% Scarred Plants	Total Number of RWW adults Captured	RWW/Core - June Sample	RWW/Core - July Sample	Avg. RWW
B	27.75	2	0.03	0.03	0.03
A	0.75	0	0	0.05	0.03
L	38.5	2	0.53	0.03	0.26
W	67.2	55	7.8	2.3	5.0
O	24	7	3.0	2.2	2.6
M	24	5	0.15	0.13	0.14
SP	71.25	224	4.5	2.1	3.3
ST	13.25	10	1.8	1.9	1.9
RES	9	11	0.2	0.5	0.4

Table 3. Key dates of sampling, leaf scarring, RWW larval populations, and trap capture data from seeding date versus floating barrier trap study, 2002.

Seeding Date	Floating Barrier Trap Sample Dates	% Scarred Plant Evaluation	RWW Larval Sampling	Total RWW Captured from Four Traps	% Scarred Plants	Avg. RWW per Core Sample
3 May	5/6 – 6/5	6/7	6/26, 7/12	0	28.5	0.73
10 May	5/13 – 6/10	6/7	6/26, 7/12	2	20	0.98
17 May	5/22 – 6/12	6/7	6/26, 7/12	1	69	1.16
24 May	5/29 – 6/12	6/12	6/26, 7/12	1	22	1.53

Table 4. Statistics from linear relationships between RWW numbers and yield loss, 2002.

Study	Seeding Date	lbs. Grain Loss per RWW Larva	% Yield Loss per RWW Larva
Re-seeded Objective 2 study	3 June	283 lbs.	3.7%
Objective 1 study – various levels of RWW	10 May	305 lbs.	4.3
RES ring study with various levels of RWW	10 May	336 lbs.	4.9

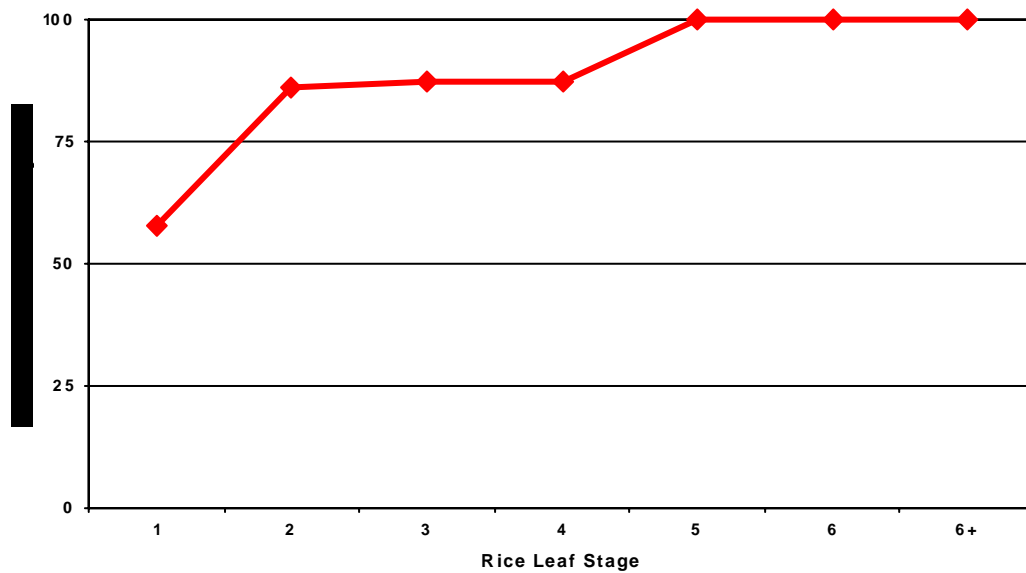


Figure 1. Percentage of RWW adults captured by floating barrier traps at various rice growth stages.

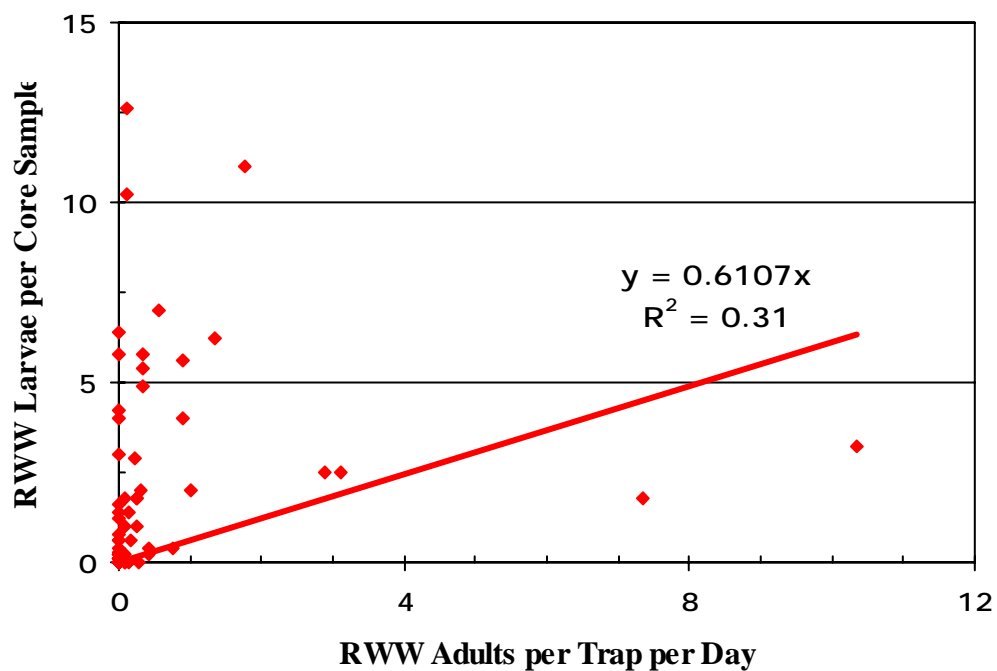


Figure 2. Relationship between RWW adult capture in floating barrier traps and RWW larval populations; summary of 9 fields, 2002.



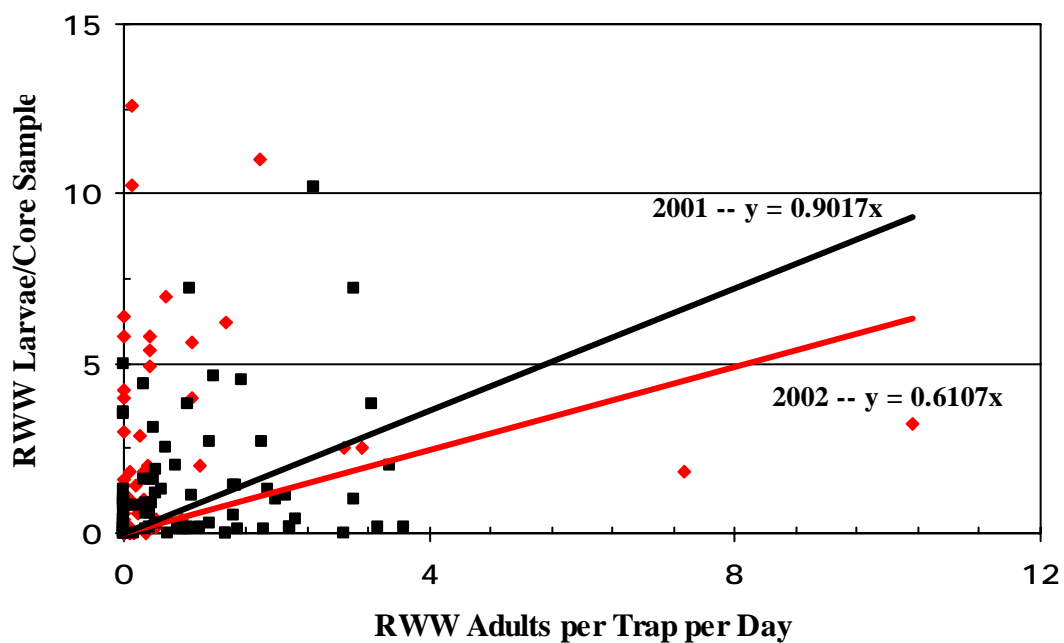


Figure 3. Comparison of results from floating barrier trap in 2001 and 2002.

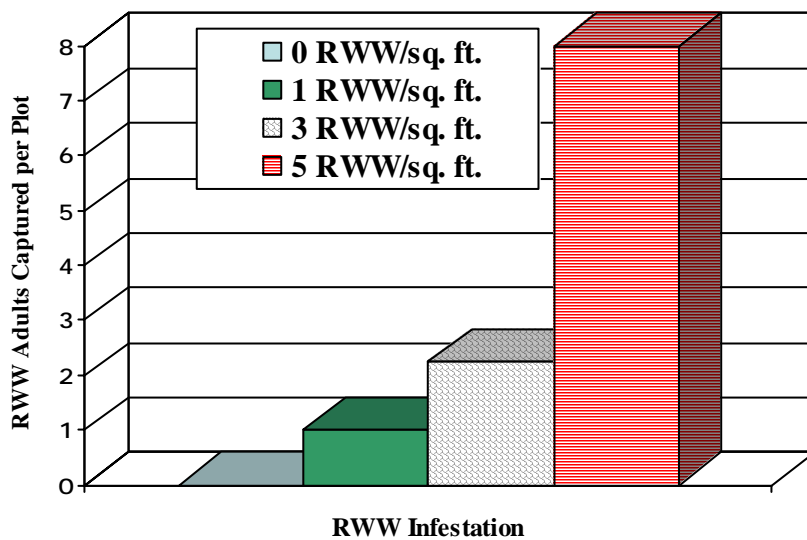


Figure 4. Influence of RWW population density on floating trap collections, 2002.

### RWW Adults per Day from Light Trap

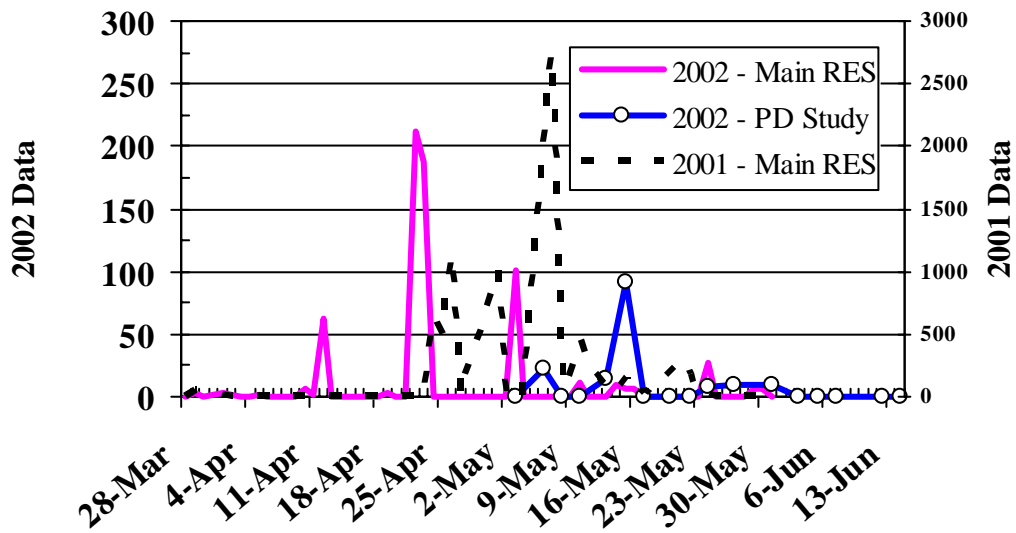


Figure 5. RWW flight timing as indicated with light traps, note that 2001 and 2002 data are graphed on different scales.